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FUEL-GAS.

A PAPER GIVING THE RESULTS OF AN EXPERIMENT WITH A  
MIXTURE OF THREE GASES.

By J. F. MERKLE, C.E., INSTRUCTOR IN CIVIL ENGINEERING.

Having demonstrated conclusively in a previous paper that coal gas is impracticable for fuel purposes, I shall in this paper give a few essential facts relative to water gas and producer gas, and their relative cost of manufacture, in order to explain certain operations which have recently been made in the United States in connection with the three gases.

Water gas, which is comparatively a modern invention, is made by passing super-heated steam over incandescent carbon, either in the form of coke or Anthracite coal. This operation is conducted in a generator very like a Siemen's producer, differing only in details of construction.

The producer consists of a wrought iron shell about nine feet in diameter and fourteen feet high. It is lined with fire brick, and contains a set of grate bars and an ash pit. A steam and a blast pipe enter the generator at the bottom and a gas pipe and waste-gas pipe have an exit at the top. The coal or coke is charged at the top of the generator.

The producer being filled with coal or coke becomes gradually heated up, the time necessary for obtaining the requisite heat being usually about twenty-four hours. When the coke becomes incandescent, and we have a sufficient depth of fuel, the air is

entirely shut off from the generator, and a jet of steam admitted *at the bottom*. The steam coming in contact with the incandescent carbon is decomposed into its elements of hydrogen and oxygen, and the latter being free, comes in contact with the carbon, forming carbonic acid ( $CO_2$ ) in the first stage, but in its passage upward through the generator, it absorbs more carbon and becomes carbonic monoxide ( $CO$ ), in which form it escapes from the generator. A large percentage of the hydrogen goes off in a free state, only a small part being used in forming the hydrocarbons.

We therefore see that water-gas is composed theoretically of fifty per cent. each of hydrogen and carbonic oxide by volume. There are many conditions which prevent this gas from ever reaching such proportions. You will observe in the first place, that *depth of fuel* is the first essential element in generating a good gas, otherwise a large percentage of it will pass off as carbonic acid, simply because it has not come in contact with sufficient carbon. In the second place the fire must be reasonably compact, otherwise the gases will escape through crevices, with a like percentage of carbonic acid. The generator must also be kept very hot or the coke will not decompose the steam properly.

Naturally a jet of steam on entering the producer will chill the fire to a great extent, and on this account the time during which steam is admitted is quite short, usually lasting about ten minutes. The steam pipe and the gas outlet are then closed, and a blast is forced through the fire to again put it in a fit condition for gas generation. The blasting period is usually of the same length as the generating period, so that a producer is only making gas for twelve hours out of the twenty-four.

An average volumetric analysis of unpurified water-gas is as follows:

Hydrogen ( $H$ )	-	-	45.00
Marsh-gas ( $CH_4$ )	-	-	2.00
Carbonic oxide ( $CO$ )	-	-	45.00
Carbonic acid ( $CO_2$ )	-	-	4.00
Nitrogen ( $N$ )	-	-	2.00
Oxygen ( $O$ )	-	-	0.50
Water vapor ( $H_2 O$ )	-	-	1.50
			<hr/>
			100.00

This gas contains ninety-two per cent. of combustibles, and yields about three hundred and twenty-two thousand (322,000) heat units per thousand feet. In ordinary practice a ton of coal or coke yields forty thousand (40,000) cubic feet which contain twelve millions nine hundred thousand (12,900,000) heat units. Since a ton of coal yields theoretically twenty-five million (25,000,000) heat units, we see that we have an efficiency of about fifty-two per cent.

The water-gas which is used commercially for illumination, is rendered so by first carburretting it with the hydro-carbons from petroleum, since uncarburretted water-gas possesses very little illuminating property.

Aside from the fact that water-gas would cost too much to employ it for fuel, there are certain other objections to its use for domestic purposes. The carbonic oxide which it contains is a deadly poison, which is capable of displacing the oxygen in the blood owing to the formation of a compound with the haemoglobin with which the oxygen is ordinarily combined. Indeed, some years ago the Legislature of the State of Massachusetts enacted a law prohibiting the manufacture of any gas for commercial purposes, which should contain more than fifteen (15) per cent. of carbonic oxide. This virtually stopped the manufacture of water gas for a time, but if I mistake not the act was subsequently repealed.

There is another strong objection to the use of this gas in houses, in that it is inoderous and therefore one has no means of detecting its presence save by its fatal effect.

#### PRODUCER-GAS.

This gas, which is made by simply passing air through incandescent coal or coke in a producer very like a water gas generator, is composed almost entirely of carbonic oxide. Air being a mechanical mixture, gives up its oxygen in the vessel and forms the oxide. Indeed, aside from a small per centage of the hydro-carbon series which are given off, carbonic oxide is the only combustible which producer-gas contains.

An average volumetric analysis of this gas made from anthracite coal is as follows:

Hydrogen ( $H$ )	-	-	-	5.50
Marsh gas ( $CH_4$ )	-	-	-	3.50
Carbonic oxide ( $CO$ )	-	-	-	23.50
Carbonic acid ( $CO_2$ )	-	-	-	1.50
Nitrogen ( $N$ )	-	-	-	65.00
Water vapor ( $H_2O$ )	-	-	-	1.00
				<hr/>
				100.00

From this analysis we see that we have a gas containing thirty-two per cent. of combustibles which yields about one hundred and twenty thousand (120,000) heat units per thousand cubic feet. A ton of coal containing twenty-five million (25,000,000) heat units, yields about one hundred and fifty thousand (150,000) cubic feet of this gas which would contain about seventeen millions four hundred and seventy thousand (17,470,000) heat units. This would represent an efficiency of nearly sixty-nine (69) per cent.

This gas has a very high specific gravity, seventy-five cubic feet of it weighing one pound. The gas can not be used alone for fuel under ordinary circumstances, since it will not ignite at a low temperature. It is, however, used quite economically in metallurgy, being cheaper than any other manufactured gas, a thousand cubic feet of it costing only about two cents.

Having shown now that not any one of these several gases can be employed for fuel, I shall give briefly the results of an experiment involving a manufacture of the three gases.

In the first place, coal-gas cannot be used on account of its cost; water-gas contains too large a percentage of carbonic monoxide; and finally, producer-gas has too small a percentage of combustibles. A combination of the three gases would diminish the cost, decrease the percentage of carbonic oxide, and would have an odor.

I shall give the figures and describe the apparatus for a plant having a capacity of a half-million cubic feet per diem.

The plant consisted of two coal-gas benches of six retorts each, one coal-gas producer, and two water-gas generators, together with an engine, boiler, pumps, etc.

The scheme was to take a ton of coal of the bituminous variety, and from this make coal-gas in the retorts. This would yield ten thousand (10,000) cubic feet of gas, and about thirteen hundred (1,300) pounds of coke, three hundred (300) of which would be



required to keep up the heats. This would leave one thousand (1,000) pounds to divide between the producer and the water-gas generators. There would be an enormous amount of heat saved in this operation, since the coke could be charged into the producers immediately after it was drawn from the retorts, and at a temperature of probably 2000°.

The producer-gas in its exit was to pass through one of two regenerators, which would become heated to a high temperature. The steam would then pass through one of these regenerators, and become super-heated before entering the generator which would make the water-gas. While the steam would be passing through one regenerator, the other would be passing gas and absorbing its heat, and *vice versa*.

In order to utilize all the available heat, the *waste* gas from the water-gas generators, which was given off during the blast, was to pass under the boiler.

A ton of coal would yield *theoretically* by this process as follows:

PRODUCT.	QUANTITY.	VALUE PER 1000'
Coal gas - -	10,000	× 750,000 = 7,500,000
Water gas - -	16,500	× 322,000 = 5,313,000
Producer gas -	24,500	× 145,000 = 3,552,500
	51,000	× 332,000 = 16,365,500

This gas mixture would have a calorific value equal to about one-fourth that of natural gas.

The volumetric analysis of this gas would be as follows:

Hydrogen ( <i>H</i> )	- - -	29.00
Marsh gas ( <i>C H<sub>4</sub></i> )	- - -	8.78
Carbonic oxide ( <i>C O</i> )	- - -	31.78
Olefiant gas ( <i>C<sub>2</sub> H<sub>4</sub></i> )	- - -	0.81
Carbonic acid ( <i>C O<sub>2</sub></i> )	- - -	2.94
Nitrogen ( <i>N</i> )	- - -	25.64
Oxygen ( <i>O</i> )	- - -	0.26
Water vapor ( <i>H<sub>2</sub> O</i> )	- - -	0.79
		<hr/> 100.00

This gas was to cost in the holder about six cents per thousand cubic feet.

The process did not succeed, and at this time it is well to ascertain wherein the practice would not agree with the theory. Of the ten tons of coal which would be used in the retorts in twenty



Let  $n$ =frog number=cot. frog angle and= $r$  cot. switch angle.

"  $S$ =length of switch rail= $AB$ .

"  $T$ = " " tangents  $BC$ = $MC$ .

"  $U$ =dist.  $MD$  from actual points of frog to end of frog rail.

"  $a+b$ =dist. of intersection pt.  $C$  from respective gauge lines.

"  $g$ =gauge of track= $a+b=4' 9''$ .

Then

$$a - \frac{S}{r} = \frac{T}{r} \quad (1) \quad \text{and} \quad b - \frac{U}{n} = \frac{T}{n} \quad (2)$$

adding (1) and (2) and placing  $a+b=g$  there results,

$$g - \frac{S}{r} - \frac{U}{n} = \frac{T}{r} + \frac{T}{n} \quad (3)$$

for convenience place  $g - \frac{S}{r} - \frac{U}{n} = P$  (4) giving

$$P = \frac{T}{r} + \frac{T}{n} = \frac{T(r+n)}{rn} \quad \text{or} \quad T = \frac{rnP}{r+n} \quad (5)$$

and, placing  $L$ =total length of lead= $ABMD$  we get  $L=S+2T+U$  (approximately.) (6).

The planing of the standard switch rail is  $2\frac{1}{4}$  in. in 6 feet 3 in., and hence,

$$r=33\frac{1}{3}.$$

$U$  and  $n$  depend on the frog number.

$U$  also being dependent on the kind of frog employed—stiff or spring rail.

The values of  $\frac{S}{r}$  corresponding to common values  $S$  are as follows:

$$\begin{aligned} \text{For } S=12 \text{ ft.} \quad \frac{S}{r} &= 6\frac{7}{8} \text{ in.} \\ &= 15 \text{ "} \quad = 5\frac{3}{8} \text{ "} \\ &= 19 \text{ "} \quad = 4\frac{3}{8} \text{ "} \end{aligned}$$

The following table gives values of  $\frac{U}{n}$ ,  $U$  and  $P$ .

Frog No. $n$	$\frac{U}{n}$		$U$		$P \left( = g - \frac{U}{n} - \frac{S}{r} \right)$					
	Stiff.	Spring.	Stiff.	Spring.	Stiff Frog.			Spring Frog.		
					$S=12\text{ft.}$	$S=15\text{ft.}$	$S=19\text{ft.}$	$S=12\text{ft.}$	$S=15\text{ft.}$	$S=19\text{ft.}$
4	7 in.		2ft. 4 in.		3.8	3.7	3.6			
4½	6½ in.		2ft. 5½ in.		3.8	3.7	3.6			
5	6 in.		2ft. 6 in.		3.9	3.8	3.7			
5½	5½ in.		2ft. 6½ in.		3.9	3.8	3.7			
6	5½ in.		2ft. 7½ in.		3.9	3.8	3.7			
7	4½ in.		2ft. 9½ in.		4.0	3.9	3.8			
8	4½ in.	10½ in.	3ft. 0 in.	6ft. 11 in.	4.0	3.9	3.8	3.5	3.4	3.3
9	4½ in.	9½ in.	3ft. 2½ in.	6ft. 11½ in.	4.0	3.9	3.8	3.6	3.5	3.4
10	3½ in.	8½ in.	3ft. 2½ in.	6ft. 11½ in.	4.1	4.0	3.9	3.7	3.6	3.5

The values of  $T$  and  $L$  as obtained from formulae (5) and (6) are given in the following table:

Frog No.	$T = \frac{rn}{r+n} P$						$L = U + S + 2T$ (approx.)					
	Stiff Frog.			Spring Frog.			Stiff Frog.			Spring Frog.		
	$S=12$	$S=15$	$S=19$	$S=12$	$S=15$	$S=19$	$S=12$	$S=15$	$S=19$	$S=12$	$S=15$	$S=19$
	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
4	13.6	13.3	12.8				41.4	43.9	46.9			
4½	15.3	14.9	14.4				45.0	47.3	50.3			
5	16.9	16.6	16.0				48.3	50.1	53.5			
5½	18.5	18.1	17.5				51.5	53.8	57.1			
6	20.0	19.4	19.0				54.6	56.5	59.6			
7	23.0	22.5	21.8				60.8	62.8	65.4			
8	25.9	25.3	24.5	22.9	22.3	21.5	66.8	68.6	71.0	64.7	66.5	68.9
9	28.6	28.0	27.0	25.7	25.0	24.2	72.5	74.2	76.2	70.4	72.0	74.4
10	31.3	30.6	29.7	28.4	27.7	26.8	77.8	79.4	81.6	75.8	77.4	79.6

On examining the above table it is seen that decreasing  $S$  increases  $T$  and decreases  $L$ , while decreasing  $U$  increases both  $T$  and  $L$ .

[It would seem at first sight that there must be some angle between those of the frog and switch angles used, for which  $L$  would remain unchanged for all values of  $U$  and  $S$ . Substituting in eq. (5) the value of  $P$  we obtain

$$T = \frac{rn \left( g - \frac{U}{n} - \frac{S}{r} \right)}{r+n} \quad (7)$$

Let this be increased by taking an increment  $U'$  then the corresponding value of  $T$  is

$$T + T' = \frac{rn \left( g - \frac{U+U'}{n} - \frac{S}{r} \right)}{r+n} \quad (8)$$

from which by subtracting (7) from (8)

$$T' = - \frac{rU'}{r+n} \quad (9)$$

Now  $L = S + U + 2T$  (6) and

$$L + L' = S + (U + U') + 2 \left( T - \frac{rU'}{r+n} \right) \text{ or } L' = U' - \frac{2rU'}{r+n} \quad (10)$$

if  $L' = 0$  then 
$$U' - \frac{2rU'}{r+n} = 0$$

$$U'(r+n) - 2rU' = 0. \quad U'n - U'r = 0, \quad \text{or} \quad r = n,$$

is the necessary condition that  $L$  be not affected by any change in  $U$ , and also (by analogy) by any change in  $S$ . This condition

means that the switch and frog angles must be equal, or that the turnout is a straight line from switch to frog point.]

It is evident that, for a given frog angle, the greater the value of  $T$ , the easier the turnout curve will be; while the less the value of  $L$ , the cheaper will be the turnout and the less the space required for it.

Since decreasing  $S$  effects both these objects, the switch rail should be as short as possible consistent with sufficient room for splicing. With the switch angle used in the above computations, the 15 ft. switch is about as short as can conveniently be employed.

M. L. BYERS, '88,

*Assistant Engineer E. & A. Div. P. Co.*

### THE PARABOLIC SEMAPHORE.

It has long been the desire of all railroad men to get a signal which would be a position and color signal by night as well as by day, since then engineers and others would not have to depend on color alone at night. If this could be accomplished, it would not matter if a man were color blind or not. The semaphore, as ordinarily used, consists of a red blade hinged to a post and at right angles to the track. When the blade is at right angles to the post it indicates danger, and when it is at an angle of forty-five degrees with the post it signifies all right. This problem has at last been successfully solved by Mr. C. H. Koyle in the Parabolic Semaphore.

This consists of a blade shaped like one-half of a parabola. This blade is divided into three parts. The middle part is a mirror, and on each side of this is a strip of wood painted red. When the blade hangs down to indicate all right the light strikes the mirror and is reflected, so that at a little distance from the signal the red part can not be seen. When the blade is up, however, for danger, very little light strikes the mirror and the red only is seen. The working of the signal at night is as follows: It is a well known property of the parabola that if a light is placed in its focus all rays of light will be reflected parallel to the axis. The axis of the parabola in this case is parallel to the track, and the lamp at night is placed in the focus of the parabola. The glass of the lamp is divided into two parts, the upper part being red and the lower part white. Now when the blade is up only the light coming through the red glass strikes the mirror, and is

reflected as a beam of red light at right angles to the post. When the blade is down, however, only the light coming through the white glass falls on the mirror, and it is reflected along the track as a band of white light at an angle of forty-five degrees with the post.

This semaphore is used by the Lehigh Valley Railroad in connection with the interlocking switch at Packerton, Pa.

A. W. STOCKETT, '89.

### STEAM HEATING OF RAILROAD CARS.

The heating of cars by steam from the locomotive is of comparatively recent origin, and after a great deal of experimenting during the last two years, the fact that cars can be satisfactorily heated in this manner has been fully demonstrated. The ultimate adoption of *some method* of heating trains by steam from the engine has been determined upon by all railroad companies (a few small roads still cling to the car-stove), and hence it is unnecessary to advocate the advantages of this method, as compared with the various devices heretofore used for warming cars by means of fires, either in stoves or in connection with hot water apparatus. There are a dozen patent heating systems in use, besides systems gotten up by some roads for their own use. Of the patent ones, the following are among the best, and are given in about the order of their use by railroads at present:—The Sewell, the Gold, the McElroy, the Martin, and the Erie systems. Two of the most important parts of a steam heating system are the couplings between the cars and the “trap” through which the condensed steam exhausts, and which is generally placed under the centre of each car. The principles upon which the practical success of a system depends are as follows: (1.) A low pressure of steam must be used, for it has been proved that systems can work successfully with a pressure of from 5 to 30 lbs; and this is necessary as the connections (especially hose) will not stand a high pressure, on account of less drain on the locomotive, and also on account of safety in case of accident. (2.) Large supply pipes—2"—2½"—must be used, as it is impossible to force steam through a long train of small pipe with low pressure. (3.) Elbows and “pockets” must be avoided as much as possible, as they increase friction and condensation. (4.) Free drainage of pipes must be provided for by giving them ample pitch. The greatest difficulty is the liability of *condensed water to freeze*, and hence a system must be simple



and drain automatically, without the necessity for manipulation of traps and valves by unskilled train hands, who know nothing of the properties of steam. Drainage should be made positive toward one point which must be the lowest in the system, and provided with a reliable trap. The number of valves used per car is often excessive; the greatest number that should be needed and can be allowed is two, while it is possible to so pipe the car that one valve to control the steam for the car will be all that is necessary. The following are some of the requirements for a good system: (1.) The temperature of the car must be kept at 70° F., even when the outside temperature is 0°. (2.) The heat must be so distributed that a uniform temperature may be maintained. (3.) There must be some means for storing heat sufficient to heat the cars for several hours, should the locomotive be detached and the train standing. (4.) The heating power must be capable of being graduated so as to suit conditions of the weather. (5.) There must be some arrangement for heating cars before starting on a trip, and for this purpose it is well to provide stationary boilers at terminals, to which the train pipe can be connected. In some cases connection may be made with an idle switch engine, which is making and not using steam. In regard to the disposition of the main pipe, it may be placed overhead or below, and in any case branches are led off for each car. The overhead system is probably the best in cold climates like in the North-west, as the drainage is better, and the pipe better protected. If this style is used, however, the coupling must be perfectly tight, so that no steam will leak and drop on the platform. If the pipe is below the car it must be well covered; this style is most convenient, is used the most, and is the best for a climate like that of Middle States. The theoretical amount of piping, or necessary radiating surface per car, calculated for the standard coach, whose length from door to door is 50' 10'', and from wall to wall 8' 9'', is about 160 square feet, or 305' of 2'' pipe, and this is but little more than the amount used in practice. The steam is taken from the drum of the boiler, so as to get it as dry as possible. There must be a reducing valve on the locomotive pipe, in order to reduce pressure for the train. The "Ross" and the "Johnson" valves are the best, and after being set by the engineer, keep the pressure uniform without further attention. The old way was to use a globe valve, which required constant attention. It has been found that the drain on the engine to heat the cars is *not*

*excessive*: the maximum being about 5% of the power for a train of 14 cars, and very low outside temperature. In some cases the steam is turned off from the train when the engine is using most, and turned on at stations and on down grades, when it would be necessary to blow off, could not steam be used in this way. Although the steam required is not excessive, the question of economy is an important element in deciding upon a system when it is desired to heat trains of ten and twelve cars.

The question whether the circulation of live steam, or water heated by steam is the best, has been much discussed. I believe the former to be the best for the following reasons: Direct steam is quicker in action, does not take so long to heat up to the required temperature as when it has first to heat a water circulation. It is also safer than hot water in case of accident. Where water is used there is great liability to freeze should the supply of steam be cut off, and the water must be heated when the engine is detached. For this purpose the "Baker heater" is generally kept in the car, and the water circulates through a coil in the heater which is above the fire. The Gold Heating Co. use storage heaters filled with a brine solution and sealed, in connection with direct steam; this solution will not freeze, and never needs replacing, and gives off heat for several hours after the engine is detached. This is a good method.

It is claimed by some engineers that the *exhaust steam* can be used to heat a train. I do not believe this is practical. This steam is needed in the locomotive to generate the draught, and another reason is that the exhaust steam transmits into the system more or less of the oil used in the cylinder, which in time coats the pipes and renders their radiation imperfect.

The best method to dispose of condensation is to exhaust from a trap under the car. The traps in present use work on the principle of a metal composition, expanding when heated by live steam and closing the discharge orifice; when steam is condensed and temperature lowered the metal contracts and water is discharged. There are some good traps in the market, but none which are entirely reliable; they do not act promptly enough at times, and hence are liable to freeze up.

It is to be hoped that designers will soon sharpen their abilities to a keen edge and give us a trap that answers all requirements. The theoretically correct trap is one which drains water off as it condenses, never leaks live steam, and keeps the pipes



entirely free from water. A method for carrying exhaust back to the tender has been tried and claimed to be better than using traps. To do this a pump must be provided on the engine for the purpose, and return piping and connections are necessary, making the expense higher, while it is also liable to freeze up. This is the principle of the Williams system, which was tried on the Pennsylvania Railroad last winter, but it has not been adopted by them. In order to get steam through a train of cars it is of the first importance to have a good *coupler*. That the coupling be steam tight is a primary necessity. It must be easily coupled and uncouple automatically should train part, and should have a straight way passage for steam. The two halves should be exactly alike.

Leakage of steam and the collecting of condensed steam at the couplings are the chief difficulties to be overcome. Of about 14 couplers on the market, 11 use hose and 3 use metallic connections. As yet it has been impossible to design a metallic connection which will meet the three motions of the car and not wear and leak steam. I am convinced that the hose coupling is the best. It gives the desired flexibility, and if made of the best material can be relied upon to stand the action of steam, with a moderate pressure, for one season. It is desirable that some coupler should be universally adopted by all railroads, or at least by each group of roads, so that all coaches on the various lines may be susceptible of interchange, as they are now in the application of the air brake; for at present the interchange of cars by lines using different systems is difficult. Of the couplers now in use I believe the McElroy to be the simplest and best. The two parts of this coupler are alike and locked by double cams, the two cam rings being provided with handles, to which are attached chords, the other ends of which are fixed to the car, so that the coupler will pull apart should the cars separate. The coupling is tight and the faces are so clamped together that all wear is taken up and the jerks of the train serve to tighten the connection. The hose is not bent and but slightly twisted in coupling and is not slack, thus minimizing the "dip" in which condensed water can lodge. The coupler is made of brass or malleable iron. With a tight system and good circulation all through, the largest train of cars (14) can be heated comfortably. The extensive investigation and development of this subject has added greatly to our knowledge of steam heating science and it has been a good topic

for discussion by engineers. In the limited time allowed here, I have only been able to touch briefly upon the principal points of a very large subject.

PEARCE ATKINSON, '89.

### THE SENIOR MECHANICALS' TRIP TO NEW ENGLAND.

The class left Bethlehem for New York, Monday, May 13th, at 6:40 A.M., via the Lehigh Valley Railroad. The day was spent in New York in visiting the Worthington Pump Works, and the Delameter Iron Works.

After a pleasant day in the city the party went aboard the steamer "Providence" of the Fall River Line, en route for Fall River, Massachusetts.

Although there was some mist, the view from the steamer was good, while going out through the river and into the Sound. But darkness came on early, and all soon left the deck for the engine-room. Part of the class had already made the necessary preparations for taking diagrams from the engine,—a single cylinder condensing engine, built by John Roach & Son. The cylinder was 110" diameter, stroke 72", R. P. M.  $16\frac{1}{4}$ , and working boiler pressure about  $22\frac{1}{2}$  pounds gauge. The vacuum was 23", and under these conditions the engine developed about 1450 I. H. P., as shown by the cards taken.

After dark the Sound was soon covered with a thick fog, which made the deck a very disagreeable place, and most of the party took to their state-rooms. On account of the fog the progress of the boat was slow and the almost incessant blowing of the fog-whistle made sleep difficult. Most of the party were not sorry when the boat finally reached the dock at Fall River. From Fall River we immediately took the train for Providence, via the Providence, Warren & Bristol Railroad.

The forenoon of Tuesday was spent in visiting the works of the Brown & Sharpe Manufacturing Co. Their milling machines with the many applications to which they are capable of being put, and particularly their use in cutting gear wheels were of great interest to us as a practical application of the theoretical principles of the subject of gear wheels. Mr. Beale described the principles and method of operating his wonderfully ingenious machine for cutting templets for gear cutters to cycloidal curves, automatically and theoretically correct. Samples of work done

by the machine show that it does the work for which it was designed in an admirable manner.

After taking dinner at the Narragansett House we went to the Hope Pumping Station to examine the ten-cylinder pumping engine at that place. This engine has five steam cylinders arranged radially around a vertical shaft, all of the connecting rods of which take hold of the same crank-pin. Driven by the same crank pin and diametrically opposite to each steam cylinder is a pump cylinder. This engine was designed to furnish a steady pressure in the water main without the use of a reservoir or stand-pipe, but has not been found to work as well as some of the simpler pumps now in use.

At the George H. Corliss Engine Works, we were shown some very fine engines in process of construction. The large bevel gear cutter was not in operation, but we were given a good opportunity to examine its construction. The methods of classifying and filing drawings used in the Corliss draughting rooms were well worth a careful study.

The party left Providence for Boston at 6.40 P.M., on Tuesday, and the next morning Mr. Sanborn, of the Boston Main Drainage Works, took us down the harbor to their pumping station, where the sewage of the city is all pumped from the main into a reservoir, with sufficient head to force it through a tunnel 143 feet below low water at Dorchester Bay and into reservoirs on Moon Island. It is confined in these reservoirs until an hour after high tide, when the gates are opened and the tide carries it out to sea, thus taking all traces out of the harbor. In the pumping station there are two high duty pumping engines designed by E. D. Leavitt, Jr., and built by the Quintard Iron Works. Their normal capacity is 25,000,000 gallons a day. There are also two low duty pumping engines of the same capacity, built by the firm of Henry R. Worthington of New York.

In the afternoon we visited the American Watch Co.'s works at Waltham, and saw the extremely delicate processes and machinery used in making watches. The automatic machines for making from steel wire, finished screws with threads so fine as to be scarcely visible to the naked eye, attracted a great deal of attention.

On Thursday morning we visited the foundries and shops of Smith & Co., at Westfield, Mass., where a great variety of steam

heating apparatus is made. The many ingenious devices in use in their shops were of special interest to many of the class since the same problems had been given them in connection with their work in machine design.

Westfield is an important center of the whip manufacturing business of the country and we had an opportunity to see the various processes in the manufacture of these gentle persuaders, at the works of the American Whip Co.

From Westfield we went to Holyoke and staid there until Friday night. This place has grown up in a few years to an important manufacturing city by reason of the power obtained from the Connecticut river at that point. We inspected the dam, the system of canals and the gates by which the water level in the series of canals is regulated. At the testing flume of the Holyoke Water Power Company we were given a fine opportunity to study the practical working of the wiers and their application to the tests of efficiency of water wheels. Each wheel using water furnished by the company is tested in this flume to determine its efficiency and the amount of water used by it, under different heads and gate openings. Each wheel thus becomes a meter, and the company is able to determine the amount of water used by its customers by taking observations of the gate opening and head on the wheel.

At the works of the Holyoke Machine Co., we saw the manufacture of the Hercules Turbine water wheel, an inward and downward flow wheel that is giving very satisfactory results wherever used and has the advantage of giving maximum efficiency with the gate three-fourths open. In their shops we were shown some interesting machines for cutting bevel gears and some very heavy hydraulic presses for making paper and cotton rolls. The material of which the rolls are made, paper or cotton, is placed loosely around cylinders of cast iron and then subjected to a pressure in the direction of the axis of the cylinder by means of a hydraulic press working under a pressure of 6500 pounds per square inch. The material is then turned in a lathe to a very smooth surface, a diamond pointed tool being used for turning. In the mills of the Holyoke Paper Co., the various processes of making different kinds and grades of writing paper were studied. A short visit was made to the Deane Steam Pump Works in examining their pumps and the methods of manufacture. Their use of emery wheels and belts for finishing sur-

faces that did not require fitting, gave excellent results at small cost. A valuable point learned there, was the method of making taps, reamers, and similar tools by placing pieces of steel for the cutting edges in a mould and casting an iron form in the mould so as to hold them. Large tools are made very cheaply by this process.

From the Deane Steam Pump Works, we went to the Merrick Thread Mills, where the various processes of making spool cotton, beginning with the raw cotton and ending with the spool of thread, were seen. The company has lately put up a new mill which is run by steam, the power being furnished by a compound condensing Corliss engine, made by Hewes & Phillips, of Newark, N. J. The engine room was finished in a manner that would have done credit to a palace, and together with the finely polished engine gave a very fine effect.

Friday night was spent in Springfield, and on Saturday morning we went to Thompsonville, where the manufacture of carpets was studied at the Hartford Carpet Works. We then went to Hartford, and visited the works of Billings & Spencer. The great variety of tools and machine parts which are produced by their process of drop forging, is remarkable, and they have brought these articles to a state of perfection, combined with cheapness, never before attainable. It was especially interesting to us as Americans, to learn that the firm has large orders from one of the largest sewing machine manufacturers in England, for their drop forged sewing machine shuttles.

The afternoon was spent in the Pratt & Whitney Co.'s works, where a great variety of interesting tools and processes were seen. Some of the most interesting were a pantograph machine, for cutting milling gear cutters to a former, and a most delicate measuring machine used in making their standard gauges. In their works the party was shown an automatic type-setting machine, which is yet in an experimental stage, but promises to do great things when completed.

At Hartford the party separated, taking different routes for the purposes of visiting friends; each went his way, feeling that he had spent a pleasant and exceedingly profitable week. The route had been planned, so as to give as great a variety and as complete a list of the interesting subjects in the line of Mechanical Engineering as could well have been done, and the pleasant weather of the week assisted in successfully carrying out the plan.



In all cases the proprietors and superintendents of the establishments visited, did all in their power to make our visit pleasant and profitable.

As we went farther from the Pennsylvania coal and iron fields, the work done was found to be more and more delicate, and the engines to drive the machinery of the most approved designs for high economy in the use of steam. The subjects which we were thus able to study, made a valuable addition to what had been learned in the shops and engine rooms, where coal is cheap and the work of the heaviest class done in the country.

C. P. TURNER, '89.

### ABSTRACT OF PROCEEDINGS.

May 13, 1889.—The Vice-President in the chair at 19:30 o'clock, and twenty-four members present. The election of officers for the following year resulted as follows:—President, T. C. J. Baily, Jr.; Vice-President, F. R. Barrett; Secretary, F. E. Fisher; Treasurer, C. E. Fink; Librarian, H. K. Landis; Alumnus Editors, H. S. Jacoby, '77, and G. F. Duck, '83; Senior Editors, A. E. Phillips and J. S. Riegel.

May 27, 1889.—The Librarian in the chair at 19:30 o'clock, with fifteen members present. Mr. G. F. Duck's resignation as an Alumnus Editor was read and accepted, and Mr. L. P. Breckenbridge was elected in his place.

A. W. STOCKETT, Sec'y.

### EDITORIALS.

IN THE retirement of Mr. Duck from the editorial staff, the JOURNAL loses one of its most enthusiastic workers. Mr. Duck has been an Alumnus Editor for the past year, and has always made his presence felt in the JOURNAL.

MR. L. P. BRECKENBRIDGE, Instructor in Mechanical Engineering, who has been chosen to succeed Mr. Duck, needs no introduction, as he has become familiar to the readers of the JOURNAL through his many interesting articles. With Mr. Breckenbridge on the staff the prospects of Vol. V. are indeed bright.

THE subject of the economic length of turnouts for split switches is one of great practical importance, and the method explained by Mr. Byers in his article in another column, has been found to give excellent practical results.

The lead of a No. 8 turnout is shortened considerably, being reduced from 76 to 69 feet. A gain of 7 feet is often of great importance in the location of turnouts in places where room is wanting or land high.

PROF. KOYLE'S semaphore, noted elsewhere, promises great reform in railroad signals, and it is to be hoped will reduce the number of disasters resulting from misplaced signals or color blind engineers. The signal has already been patented in the United States, and the inventor is about to patent it in Europe.

THE *Railroad Gazette*, in its issue of June 7, gives a lengthy review of Professor Merriman's Treatise on Hydraulics, lately published by John Wiley & Sons, from which we make the following extracts:

"Professor Merriman has here given us a well-arranged, clearly expressed and full exposition of the principles of Hydraulics. Prepared evidently for students in his classes, it is none the less valuable for engineers of long practice as a book of reference in daily work. The latest experiments and analytical investigations are drawn upon, and the sources of information are referred to specifically in foot-notes, so that the original data can be consulted by those who desire to pursue any special subject more fully than it could be given in the text consistently with the scope of the work. As compared with any previous text-book on Hydraulics this one appears to be very far superior in completeness, conciseness and logical arrangement. \* \* \*

\* \* A noticeable feature in the work is the frequent reference to the investigations of American scientists in the determination of hydraulic formulae, many of the most valuable contributions having been published in the *Transactions* of the American Society of Civil Engineers. \* \* \* \* \*

\* As a whole the book is the most valuable addition to the literature of hydraulic science which has yet appeared in America, and we do not know of any of equal value anywhere else."

## ALUMNI NOTES.

1875.

—Joseph Morrison, C.E., has been appointed Resident Engineer of the Wabash Western Railway, with headquarters at Kansas City, Mo.

—Francis S. Pecke, C.E., Hydraulic Engineer, is the City Engineer of Watertown, N. Y.

1883.

—George G. Hood, C.E., an Assistant Engineer on the Central Railroad of New Jersey is now located at Mauch Chunk, Pa.

1884.

—Henry B. Douglas, E.M., has gone South again, having accepted the position of Superintendent of the Coal City Coal and Coke Company's Mines at Jasper, Walker Co., Ala.

—John A. Jardine, E.M., has removed to Village Springs, Blount Co., Ala.

1885.

—Clarence M. Tolman, M.E., has changed his address to Care of Ingalls and Williams, Summer Street, Lynn, Mass.

1886.

—Henry G. Reist, M.E., sailed for Europe on May 29, with the Engineers' Excursion. Communications addressed to Mount Joy, Pa., will reach him.

1887.

—B. A. Cunningham, C.E., is stationed at present at New Ringgold, Schuylkill Co., Pa., being on the Engineer Corps of the Schuylkill & Lehigh Valley Railroad.

—Mason D. Pratt, C.E., formerly Assistant Engineer for the Johnson Steel Street Rail Company, of Johnstown, Pa., has recently entered into co-partnership with M. Tschirgi, Jr., C.E., City Engineer of Dubuque, Ia. The firm is known as Tschirgi & Pratt, Civil and Sanitary Engineers.

—Elmer E. Snyder, C.E., has removed to Pensacola, Fla., having been promoted to the position of Roadmaster of the Pensacola Division of the Louisville & Nashville Railroad.

1888.

—L. R. Zollinger, C.E., is in the Assistant Engineer's Office of the Pennsylvania Railroad at Harrisburg, Pa.



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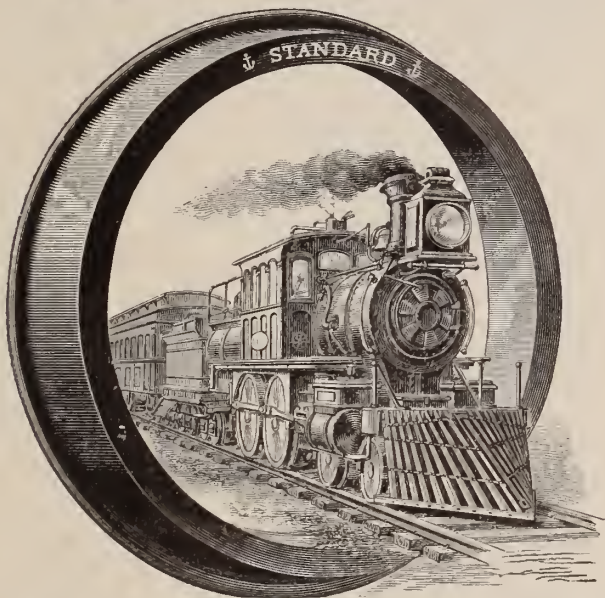
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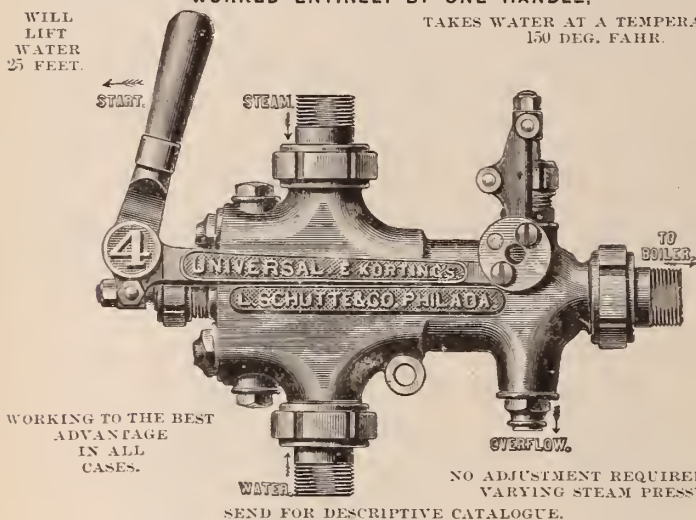
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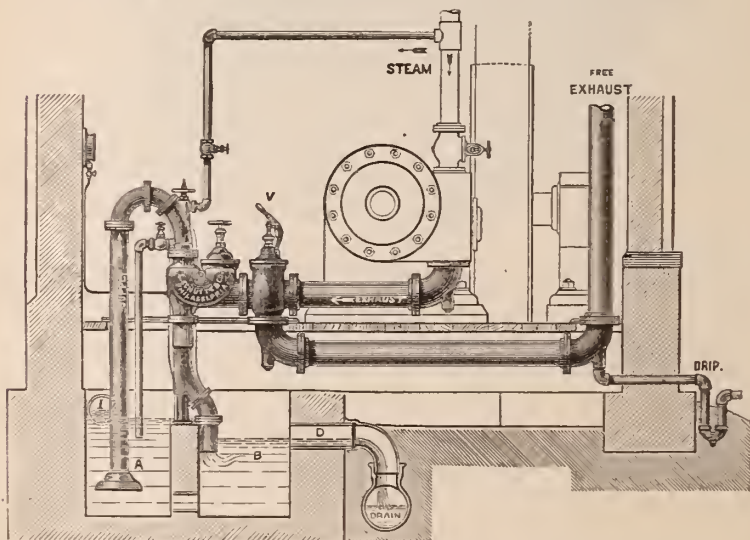
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